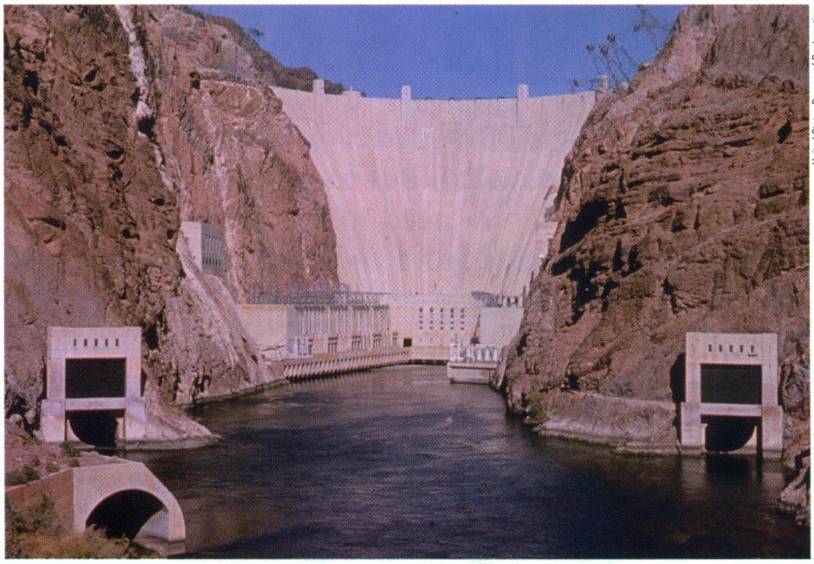
IS IT WORTH A DAM?

In 1936, the first mega-dam, the Hoover Dam, was built on the Colorado River in Black Canyon, near what was then the little town of Las Vegas, Nevada. Standing 221 m high, three times the size of the Statue of Liberty, it was the largest dam in the world. Its massive concrete walls held back the waters of Lake Mead, a 160-km-long body of water heavy enough to bend the earth's crust. Nine more large dams diverted the Colorado River's water into Arizona, Nevada, and southern California, fueling the growth of major cities and helping to turn the arid West into a lush and lucrative garden.

The Colorado dams were part of a dam-building fever that encompassed the globe. Dams harnessed the world's major rivers, including the Danube, the Nile, the Zambezi, the Yangtze, and the Ganges. Like Indian Prime Minister Jawaharlal Nehru, postcolonial leaders saw them as the new "temples of development," monuments to a nationalistic vision of modernization and unlimited growth, and vigorously promoted their construction. By 1989, the Hoover Dam was only 15th in the list of the world's largest dams.

According to Patrick McCully, campaigns director of the Berkeley, California-based International Rivers Network, over 800,000 dams have been constructed worldwide for drinking water, flood control, hydropower, irrigation, navigation, and water storage. But since the 1950s, the peak of the big dam era, perceptions of dams and dam building have changed. Once symbols of development, dams today symbolize, for some critics, not progress but environmental and social devastation. The benefits and detriments of dams have locked opponents and proponents in hot debate.

Decisions on dam building, once the province of governments and bureaucracies, are becoming a public process involving many stakeholders with different priorities. All stakeholders need a clear understanding of the possible benefits and potential consequences of dams, as well as alternatives to dams, if they are to achieve a rational, sustainable solution.



United States Bureau of Reclamation

Shifting points of reference. Once the biggest dam on earth, the Hoover Dam, built in 1936, now appears unremarkable compared to some of the world's more recently built mega-dams.

Dams and Civilization

Farmers and rulers have been impounding water for millennia. Eight thousand years ago, the Sumerians built an irrigation-based civilization between the Tigris and Euphrates rivers, then lost it to the salinization that now plagues some 20% of Iraq's arable territory. By the first century BC, low dams had been built in the Mediterranean, the Middle East, Central America, and China.

Limited technology kept their height down: a fifth-century Sri Lankan dam, 34 m high, was the world's highest for a millennium.

The age of hydropower and large dams emerged following the development of the turbine in 1832. By the turn of the century, hydro plants were operating in the United States, Italy, and Norway. Improvements in turbine design ushered in the mega-dam boom in the 1930s. As dam-building technology spread, fairly autonomous government agencies like the Bureau of Reclamation and the U.S. Army Corps of Engineers, and river management agencies like the Tennessee Valley Authority (TVA), became the model for water management authorities worldwide.

Today, most of the world's large rivers are dammed. Of large rivers in the United States, only one—the Yellowstone—flows freely along its 1,000-km length. Worldwide, some 40,000 "large" dams (over 15 m high, according to the International Commission on Large Dams) and about 800,000 smaller ones have been constructed. According to McCully, the dams impound a total of over 400,000 km^2 of reservoirs—the area of California—with an estimated capacity of as much as 10,000 km^3, five times the volume of all river water.

The Dam-busters' Debate

The original purposes of dams were to improve human quality of life by providing drinking water and to support economic growth by diverting water for power, navigation, flood control, and irrigation. In many ways, dams have succeeded. For example, the fields of Western farmers feed the United States and many other parts of the world, and India's irrigation systems have enabled that country to be self-sufficient in food production since 1974. In addition, in many parts of the world dams have helped to remedy life-threatening problems such as poverty from lack of economic development, famine as a result of drought, devastation from floods, and continued disease from lack of potable water supplies.

United States Army Corps of Engineers, Portland District

In the interest of fish. Many dams, such as the Bonneville Dam, incorporate fish hatcheries (above, lower right) into their design.

But the adverse effects of river impoundments—disruption of ecosystems, decline of fish stocks, forced resettlements, and disease—have of late made dams symbols of corporate and governmental hubris. In his 1993 book *Desert Cadillac* (the basis for a 1997 public television series of the same name), author Marc Reisner charges that dam-building agencies like the Bureau of Reclamation and the U.S. Army Corps of Engineers "greened" the U.S. West, with often disastrous ecological and social results. "We can't imagine how dependent we've become on the liberties we've taken with the natural order," Reisner states in the TV series.

Opponents of dams, so-called "dam-busters," charge that government agencies, utilities, and international loan agencies such as the World Bank have created a network that fosters irresponsible and self-serving decisions when it comes to dam building. "When I studied engineering, dam building was presented as a rational process, but most dam building is driven by greed, or a dictator who wants a project," says Bill Jobin, an engineering consultant with Blue Nile, an environmental and engineering consulting company in Dolores, Colorado. Jobin criticizes governments and lending agencies for "compartmentalization," or failing to consider the full range of consequences, including human health and environmental costs, in deciding whether to build a particular dam. He says this leads to "bad" dams—dams that ignore high environmental or human costs—being built despite their predicted consequences. Referring to the fact that the World Bank recently pulled out of a number of dam-building agreements because of environmental and social costs, he says, "With the World Bank's stance, you'd think they'd know the score. But when it gets down to the loan officer, he just says, 'let's go.'"

Some critics charge that many of the promised benefits of dams built during the first part of the century have not materialized, often because the engineering and planning studies supporting such dam projects were seriously flawed, if not contrived, according to Sam Flaim, an economist and engineering consultant based in Golden, Colorado. "The benefits of dams for flood control and navigation were exaggerated by bureaucracies who were in the business of getting dams built," Flaim says. "[Dams] were widely perceived as beneficial, and those benefits are now being

World's Highest Dams

Order	Name	River	Country	Type	Height (m)	Year Completed
1	Kogun	Vakhah	Russia	E-R	335	UC
2	Nurek	Vakhah	Tajikistan	E	300	1980
3	Grand Dixence	Dixence	Switzerland	G	285	1961
4	Inguri	Inguri	Georgia	A	272	1980
5	Chicoasen	Grijalva	Mexico	R	261	1980
6	Tehri	Bhagirathi	India	E-R	261	UC
7	Kishau	Toas	India	E-R	253	UC
8	Ertan	Yalong Jiang	China	A	245	UC
9	Sayano-Shushensk	Yenisei	Russia	A	245	UC
10	Guavio	Guavio	Colombia	R	243	UC

Type: E = Earthfill, R = Rockfill, E-R = Earth and Rockfill, G = Gravity, A = Arch
UC, under construction
Source: National Performance of Dams Program/Stanford University at **http://npdp.stanford.edu/** and the U.S. Committee on Large Dams Register of Dams

questioned. Also, what was once perceived as a benefit—interruption of natural stream flows—is now perceived as a cost." Flaim adds, "Dams achieved exactly what the planners and engineers intended—interrupting large annual changes in stream flows so water would be available all year. Now we look at those realized intentions as negative consequences. But there have been unforeseen benefits in the environment, too: an increase in food and habitat for raptors, trout fisheries. Dams are here now; the issue is how to use them."

Dam-busters, proponents say, must remember that, without the economic and social benefits that dams provide, much development would be impossible. "You have to think of the benefits of dams in monetary terms," says Earl Eiker, chief of hydraulics at the U.S. Army Corps of Engineers. "If you're going to have sustainable development, you can't leave the environment totally pristine. This is a trade-off that we must accept, though impacts on the environment can and should be minimized. But without water resources development, this country wouldn't be what it is today. We all like to know that we will have water when we turn on the taps, or lights when we flip the switch."

It is impractical and poor strategy to oppose all dams on principal. "Dam opponents make a serious mistake when they don't raise the right issues, and distinguish between different types of dams," says Robert Tillman, senior environmental specialist for Africa at the World Bank. "There are more good dams than bad ones. The bad dams are the shallow ones that flood large areas of land, or that produce relatively little power. It's in the tropics that these dams are associated with diseases like schistosomiasis and malaria; these are not a problem in temperate areas. We also need to revisit the definition of large dams: you can't call a 10-meter dam large when you have 190-meter dams. And with proper mitigation, dam sites can be improved."

The Biology of Impoundment

Dams change the chemical, physical, and biological processes of river ecosystems. They alter free-flowing systems by reducing river levels, blocking the flow of nutrients, changing water temperature and oxygen levels, and impeding or preventing fish and wildlife migration. These changes can be beneficial or tragic, depending on your perspective.

In its wild days, the Colorado River was a silty, warm flow of water that ran 2,300 km, ending in a rich delta in Mexico. Today, northern Mexico gets only a meager allotment of water that has been recycled for irrigation as many as 18 times, according to Reisner, and the delta is dry except in years of exceptional rain. The 10 dams on the Colorado have turned its water clear and cold, inimical to the fish that evolved to live it, such as the bonytail chub and the Colorado squawfish. Nonnative vegetation, especially tamarisk—small shrubs and trees native to Eurasia—has invaded the banks.

Notoriously, large dams like those on the Colorado have contributed to huge declines in anadromous fish (those that live in the sea but swim inland to historic spawning grounds) such as salmon, shad, steelhead, and sturgeon. Dams are not the only culprit—pollution and overfishing have also contributed—but the combination has virtually eliminated shad and sturgeon from the U.S. Atlantic coast, and salmon from many rivers in Europe and the American West and Northeast. In some areas, such as the Chesapeake Bay watershed, stocked fish are trucked to their spawning grounds.

Things are improving in the United States, where environmental laws and public pressure have forced utilities and bureaucracies to restore some of the natural flow of riverine ecosystems. In developed countries, technological fixes have also yielded results. The TVA has become a leader in various technologies to return dissolved oxygen to tailwaters (water flowing out of dams). And a simulated spring flood released in March 1996 in the Grand Canyon increased the volume of existing sandbar habitats by over 50%, and created new backwaters for native fish. According to the July–August 1997 issue of the *Bay Journal*, utilities and the public spent $50 million over a period of 20 years for fish elevators and passages on the Susquehanna River. In 1997, 100,000 shad swam up the Chesapeake Bay to their Susquehanna spawning grounds, up from a total catch of 167 in 1984.

But developing countries—in Asia, for example, where stocks of the migratory (and commonly eaten) hilsa shad have declined—cannot afford such expensive retrofits. Also, restoration of river ecosystems in the United States has created conflicts between environmentalists, who want to restore the natural system, and recreational groups, who are accustomed to swimming, boating, trout fishing, diving, and water skiing in thousands of artificially created lakes and rivers. Recreational water users favor the preservation of new resources like these for sport activities. "Some priorities for management seem mutually exclusive," says Flaim. "[On the Colorado], environmental assessments always focus on native fish that like warm, turgid water. Sport fishermen prefer game fish like trout, which thrive in cold water. They tried to restock native fish where sediment load and temperatures were higher. But the sport fish eat the [young] of the native fish."

Conflict between environmentalists and proponents of regional power and agricultural uses, Flaim says, is the result of development and rising environmental awareness. "Once, [dam building] was a question of survival. Now we're trying to get the maximum value from natural resources. Values today reflect preference for environmental attributes as well as economic development."

Water Quality

Diving and recreational fishing are scarcely concerns for the majority of people in developing countries, however. What they need is clean, potable water. By some accounts, an estimated 1 billion people in the world do not have access to potable water. And that means that reservoirs are needed, Eiker says. "You can obtain water directly from a big river, like the Ohio or the Mississippi, where there's enough continuous flow. But most major cities get their water from reservoirs created by dams."

In drought-ridden countries, reservoirs are vital for community and urban water storage, and new ones will likely need to be created to respond to population expansion and the push for agricultural development. But reservoirs can be difficult to maintain—reservoirs from large dams in drought-ridden areas evaporate huge quantities of water—and often result in increased environmental problems and human health risks. Worldwide, a common problem with reservoirs is that they trap nutrient-laden sediments behind the dam. This reduces reservoir volumes and accelerates a cycle of eutrophication (or oxygen depletion) that results in increased plant and algal growth, bacterial decomposition that consumes oxygen, and release of phosphorus that nourishes further algal growth.

"There's a massive buildup of organic matter in the sediment," says Clifford W. Randall, the C.P. Lunsford professor of environmental engineering at Virginia Polytechnic Institute in Blacksburg. "This can happen in any impoundment. You can have high levels of dissolved oxygen at the top from the algal growth, and ten feet below that—zero. So the top ten feet are the only habitable area for fish. What's more, when they decay, algae release organic compounds that are precursors for potentially carcinogenic trihalomethanes when the water is chlorinated for drinking."

Tropical reservoirs and the irrigation networks they feed are also ideal breeding grounds for mosquitoes, snails, and flies, the vectors that carry malaria, schistosomiasis, and river blindness. Incidence of schistosomiasis, the long-term consequences of which can include pulmonary lesions, liver failure, and bladder cancer, has nearly doubled since the 1940s. A total of 200 million people in 75 countries are infected today, and 500–600 million are at risk, according to an article by G. Thomas Strickland, director of the international health program at the University of Maryland School of Medicine, that was published in the 7th edition (1991) of *Hunter's Tropical Medicine*.

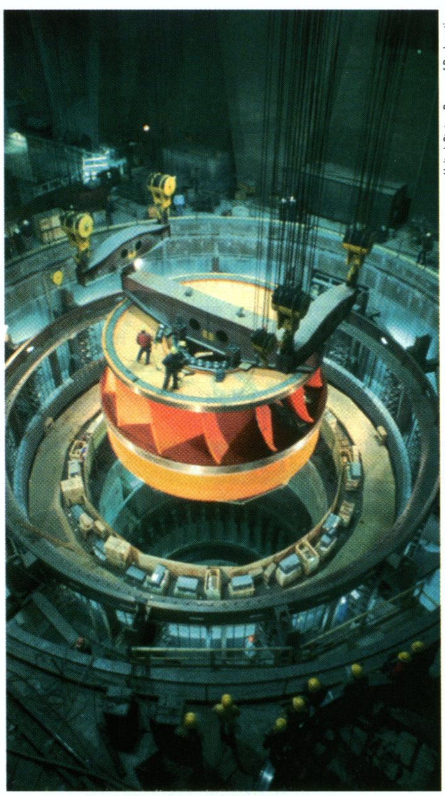
In many instances, infection can be directly correlated to the slow-flowing, reed-filled waters of irrigation canals. The absence of adequate sanitation only compounds the problem. Randall cites studies he conducted near a large drinking and irrigation water reservoir in Kenya. "There was no waste disposal, with . . . excreta from humans and cattle in the water. It was found that 78% of school children had one or more forms of schistosomiasis, and over 80% had one or more forms of malaria." Randall adds that behavioral solutions like keeping cows away from reservoirs and using sanitary latrines would prevent schistosomiasis, but people often don't have access to or use such technology. Lori Pottinger, editor of the magazine *World Rivers Review*, published by the International Rivers Network, says, "Too often, governments in developing countries invest huge amounts of money in costly large-scale river development projects like dams and irrigation schemes, rather than investing in low-tech programs like water supply and sanitation for communities."

Governments in developing countries, which are generally weak in health care infrastructure, cannot respond effectively to reservoir-related epidemics. Nor are reservoir-related illnesses confined to developing countries. Outbreaks of cryptosporidiosis, a parasitic disease associated with fecal–oral contamination, have been linked to drinking water in the United States, most recently in Las Vegas in 1995. These emerging hazards are related to urban growth and changing water uses. "What's happening in the watershed is happening in the reservoir," says James F. LaBounty, manager of the Bureau of Reclamation's research and investigation group. "As Las Vegas has grown, it's dumped [domestic and industrial] treated effluent into Las Vegas Wash, and pesticides, endocrine-disrupting chemicals, and rocket fuel go into the groundwater. This water flows into Boulder Basin [a portion of Lake Mead], and it may be contaminating Las Vegas drinking water. We're getting into new uses for water that used to be used for irrigation and power, and we need a better understanding of reservoir biology."

Hydropower: Clean Energy or Destroyer?

In addition to the water they provide, dams also provide energy in the form of electrical hydropower. According to the World Bank, hydropower constitutes 13% of electrical power in the United States, 99% in Norway, 75% in New Zealand, and 70% overall in Latin America. The U.S. hydropower industry promotes hydropower as a clean, renewable, reliable energy source that produces 19 gigawatts of electric power annually worldwide. Industry figures say that the U.S. annual capacity of about 92,000 megawatts produces as much electricity as 500 barrels of oil or 150 coal power plants, and prevents the emission of over 200 million tons of carbon dioxide annually.

Hydropower has been shown to be efficient. World Bank figures show that it converts mechanical energy into electrical energy at 85% efficiency (TVA figures are 90–92%), compared to 50% efficiency for gas turbines. Once constructed, hydro plants are inexpensive to run. The hydropower of Western rivers helped the United States win World War II: the Bonneville and Grand Coulee dams fueled enough aluminum processing to build 60,000 planes, and at the power plant on the Hanford Reservation near Richland, Washington, energy from the Columbia River produced the plutonium that ended the war.



United States Bureau of Reclamation

By the old millstream. Hydropower has come a long way in the last century, but is it far enough?

But increased understanding of the effects of large-scale inundations of dam waters has qualified claims about the reliability and cleanliness of hydropower. According to Pottinger, hydropower plants are often unsustainable in countries where frequent droughts cripple power production. A notable example, she cites, is the Akasombo Dam in Ghana, whose power plant has suffered severe drought-caused power outages for years, resulting in blackouts and interruptions in power to businesses and homes.

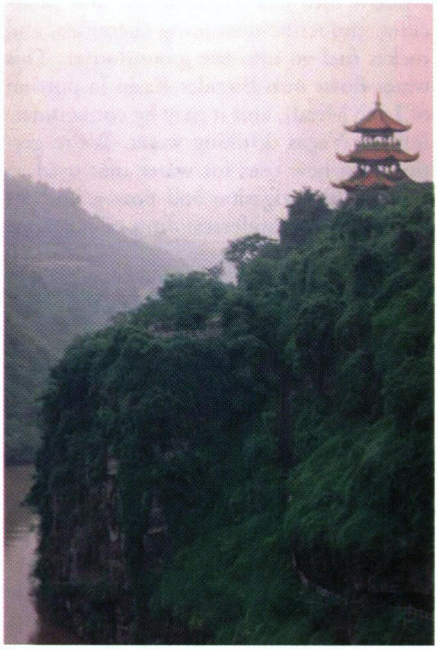
Then there are health issues. In general, hydropower produces little carbon dioxide, except for the cement and steel used in construction, according to Robert Goodland, environmental advisor to the World Bank, in the spring/summer 1997 issue of *Civil Engineering Practice*. However, large, shallow reservoirs, especially in the tropics, can generate large amounts of greenhouse gases from the decay of biomass. A 1996 study at the University of Manitoba, described in the May 1997 issue of *Environmental Science*, provides evidence that, even in temperate zones, inundating wetlands changes them from net sinks to major emitters of carbon dioxide and methane gases, and increases the catalysis of methylmercury, a nerve toxin, from inorganic mercury in sediments. "The worst hydropower projects may produce more [greenhouse gases] than a coal-fired equivalent," Goodland writes.

Critics also take issue with the claim that hydropower comes cheaply. Historically, planners for large dams have ignored numerous additional cost factors, including potential structural difficulties, human resettlement costs, and environmental consequences. By all accounts, dam building in developing countries is fraught with corruption. Dam construction also frequently costs more and takes longer than anticipated, sometimes to a grotesque degree. For example, the cost of building Brazil's Itaipu Dam, estimated at $3.4 billion over 15 years, expanded to $20 billion over 18 years. Since capital costs represent about 80% of expenditures over the lifetime of a hydrodam project, such cost overruns are a serious issue. Dam opponents add that the cost-effectiveness of hydropower is further eroded by subsidies for industrial users and, sometimes, by considerable siltation, which can reduce dam capacity, thereby diminishing generating power, or deplete downstream farmlands, which are dependent upon silt for nutrients.

Technological solutions such as dredging and mixing, though expensive, can alleviate these problems in existing dams. But more importantly, says Jobin, new dams should incorporate understanding gained from past mistakes. "When you build a dam to fit the season of the river—a low dam or a gated one—it can pass the sediment," he says. "But many dams are built without bottom outlets, just a spillway at the top."

One of the most serious charges against hydropower, though it applies to all dams, is its high social cost in terms of involuntary resettlement. McCully estimates that 30 million people have been ousted by dams. Most often, "oustees" are poor or indigenous people who often leave behind productive farms and ancestral homes. Opponents claim that, though these groups pay the social and environmental costs of dam construction, they don't receive the benefits—instead, those go to urban areas and industries. The Aswan High Dam ousted 100,000 people, according to the World Bank, and the planned Three Gorges Dam in China, a 600-foot-thick, mile-wide project so large it will be visible from outer space, will expel 1.3 million people from the area.

Opponents claim that relocation can be a death sentence to a community. Says Jobin, "The dislocation itself causes mental and spiritual problems. Twenty years after [about 90,000 people were] relocated for hydroelectric power projects in Ghana, none of them could be found. They'd migrated to cities, or died. You'd think this only happens overseas, but it's happened [in the United States] with Indian tribes."



Margaret Barber/Probe International at http://www.nextcity.com/ProbeInternational/index.html

The great dam of China. The Three Gorges Dam, planned for China, will be large enough to be seen from outer space.

The World Energy Commission predicts that global energy consumption will likely double between 1990 and 2020, with demand growing fastest in less developed countries. With international consensus developing over the potential for global warming, well-designed hydropower plants can still provide cleaner power than other fuels, except possibly natural gas.

Development organizations and the dam industry agree on the need to identify and internalize the environmental and social costs of dams, even if that means not building some dams. "There needs to be an honest assessment of costs," says Tillman. "With oil prices low, you can figure that if your construction involves more than $1,500–2,000 per kilowatt hour, it's unlikely to be economically feasible."

Tillman adds that when countries can agree, cross-boundary water sales or water sharing could furnish an incentive to find "good" dam sites that provide power without demanding resettlement. Numerous arrangements for interstate water exchange exist in the United States, and a number of developing countries, including South Africa, Uganda, and Paraguay, sell or resell excess hydropower.

Flood Control, Irrigation, and Economic Growth

Historically, dams and the lakes they create have protected growing populations from the unpredictability and violence of rivers' seasons. In warm regions, stored floodwaters can supply enough irrigation for a year-round growing season. Reisner reports that California's San Joaquin Valley, once a swampland with seasonal flooding, now provides a quarter of America's food through intensive ground- and surface-water irrigation. Egypt's Aswan High Dam has provided power, irrigation, and the water supply for a growing population for almost 30 years, with three yearly crops including high-yield grains or water-intensive cash crops like sugar cane and rice.

However, though irrigation is appropriate in rain-rich lands, in arid climates it can result in salinization of soil and water, stunting or killing crops unless even more water is used to flush the salt out. And over-irrigation, combined with the loss of nutrient-rich sediments through natural flooding, can also cause numerous downstream changes. According to journalist Fred Pearce's 1992 book *The Dammed*, the Aswan High Dam's impoundment of 120 million tons of silt has vastly depleted the Egyptian sardine industry's fish stocks, which once fed on organisms that were nourished by the 30,000 tons of silt deposited each year in the Nile delta. Pearce adds that the absence of silt has also made Egypt dependent on chemical fertilizers, at the rate of 175 kg per hectare on some 25,000 km^2 of farmland. Overwatering deposits 1 ton of salt per hectare per year on some lands, while the growth of Cairo, fueled by Aswan's water and power, buries fertile land that could be farmed. Pearce reports that Egypt has become a net importer of food.

According to the United Nations' Food and Agriculture Organization, 10% of the 270 million hectares of lands irrigated globally are damaged by salinization, and another 20% are showing symptoms of damage. Though gene modification and development and cultivation of salt-resistant plants can address some of these problems, they do not yet promise a sustainable

World's Largest Hydropower Projects

Order	Name	River	Country	Capacity (MW)	Year Completed
1	Itaipu	Parana	Brazil/Paraguay	12,600	1983
2	Guri	Caroni	Venezuela	10,300	1986
3	Sayano-Shushensk	Yenisei	Russia	6,400	1989
4	Grand Coulee	Columbia	USA	6,180	1942
5	Krasnoyacsk	Yenisei	Russia	6,000	1968
6	Church Falls	Churchill	Canada	5,428	1971
7	La Grande 2	La Grande	Canada	5,328	1979
8	Bratsk	Angara	Russia	4,500	1961
9	Ust-Ilim	Angara	Russia	4,320	1977
10	Tucurui	Tocantins	Brazil	3,960	1984

Source: National Performance of Dams Program/Stanford University at **http://npdp.stanford.edu/** and the U.S. Committee on Large Dams Register of Dams solution. Experts say that water conservation techniques such as recycling and drip irrigation can maintain productivity using 30–50% less water. But critics question a vision of development that demands large allocations of water to ecosystems that are hostile to cultivation.

Nor does irrigation address the issue of over-allocation of water. When countries share water, over-allocation combined with new upstream uses can threaten not just human health, but political stability. Egypt, for example, is the last of nine countries through which the Nile flows. If Ethiopia makes good on its intention to dam the Blue Nile, Egypt could lose water on which it depends. Sandra Postel is a senior fellow at the Washington, DC-based Worldwatch Institute, which publishes the journal *World Watch*. In an article in the July 1993 issue of *World Watch*, Postel writes, "As Egypt's water security becomes increasingly jeopardized by new projects in Ethiopia, tensions between the countries are sure to build."

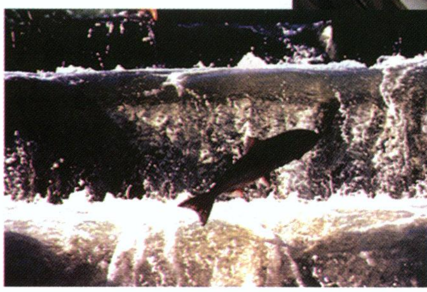
Government and water-management planners have yet to address the full spectrum of how to sustainably manage increasing demand. "If water is over-appropriated, why do we continue to build without restriction?" says LaBounty, referring to projects in the western United States. "There's no really good answer. What we need to do is to manage water properly from the inside, starting at the sanitation districts and water boards, and working up through the state legislation."

Ultimately, the vision of ever-expanding agricultural growth will need revision. "Large irrigation schemes have proven not to be cost-effective compared to smaller, locally controlled operations," says Tillman. "The ideas in [E.F.] Schumacher's *Small is Beautiful* [a 1973 book that promotes smaller, locally controlled production schemes as working more effectively] are coming back in."

Water and the Future of Development

Dam opponents have seen many victories recently. In the United States, dam-building decisions are becoming increasingly public. Representatives of environmental and recreation organizations, utilities, engineers, and the dam industry negotiate decisions on the construction and relicensing of dams. In June 1997, public input resulted in a federal decision to remove the 3.5 megawatt Edwards Dam in Augusta, Maine, a change that is expected to benefit nine species of migratory fish. Worldwide, protests against the social, environmental, and economic costs of dam building and refurbishing have led to the removal of dams or cancellation of dam-building projects. In April 1997, in a move applauded by the environmentalist community, the World Bank agreed to the creation of an independent commission to review the soundness of dams and dam projects. The commission will review existing, ongoing, and proposed projects (not just the World Bank's), and recommend ways of redressing damage to populations and natural systems that have been adversely affected by dams. The commission is to be launched in November 1997. Its members, who will be selected by an interim joint World Bank and World Conservation Union staff, will include World Bank officials, critics of large dams, and representatives from both dam-building agencies and populations affected by dams.

Deregulation of energy prices, the absence of good sites, and requirements that utilities pay for nonpower benefits resulting from harnessing a river's strength—which includes benefits that are largely recreational, such as sport fishing, rafting, boating, and wildlife programs—will likely diminish the attractiveness of dams, especially hydropower dams, in developed countries. Hydropower development in the United States is now stagnant, although the Department of Energy estimates that many thousands of power plants could be added to existing dams. Overseas, however, the demand for dams is still strong, particularly in Asia. Given the weak infrastructures and lax environmental laws there, the potential for continued underestimation of environmental and social costs concerns many dam critics. "Compliance [with international standards] is the biggest issue," says Tom Russo, special assistant to the director at the Office of Hydropower Licensing at the U.S. Federal Energy Regulatory Commission, which regulates privately owned hydropower dams. "Countries need dams for water and power. And they can do them well or miserably. We need to build up the institutions overseas to improve construction and deal with health and social problems that come up once they're constructed. That's a long-term project—10 or 15 years."



U.S. Army Corps of Engineers, Pacific Salmon Coordination Office at http://www.nwd.usace.army.mil/ps/colrvbsn.htm

Stairway to heaven. Fish elevators, such as this one at the John Day Dam, allow migratory species to continue to visit traditional spawning grounds.

Rational decisions about dam building will require a review of the attitudes that led to their construction—attitudes on the sustainability and feasibility of large-scale development. Though developing countries need energy and water, their long-term sustainability also depends on other factors. "I go into energy projects thinking there must be a better way [than building a new dam]," says Tillman. "You ought to be able to take a country and say, 'Use more efficient technology. Stabilize your population. And make sure that your bills are going to be paid.'"

Proponents and opponents generally agree that the large dam era is probably over. But dams are not likely to go away for a while. "Like it or not, we'll have to build more. And developing countries will probably need big ones," says Jobin. "But in the U.S., we have a good record of what happens when you build with short-term interests, and we can see the mistakes we made. We ought to learn from them."

Stephanie Joyce